Content Browsing in Digital Media Players

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Abstract

Contemporary personal content libraries can hold tens or even hundreds of thousands media items. It is increasingly difficult to locate individual items from a collection of this magnitude, resulting a great demand for usable and attractive content browsing user interfaces. This paper evaluates 14 consumer oriented media player appliances and applications in order to find common patterns behind their conceptual models, views and UI widgets. The evaluation method is informal, using hands-on testing, user manuals and video review material. Unifying conceptual model is then extended with external content aggregation. It was found that the players have generally identical models, views and widgets, but the look and feel layer allows product differentiation. It might also be beneficial to support non-deterministic and content analysis based methods to augment the basic hierarchical and metadata based browsing model.

1. Introduction

An average gigabyte of storage space can hold 500 photos, 250 songs or 1.25 hours of video, or any combination thereof. As the price of storage continues to drop rapidly, and less physical space is required per gigabyte, 100 GB hard disks on portable devices are soon commonplace, and network disks with terabyte capacity have been available for some time already. Equalling 50,000 photos, 25,000 songs or 125 hours of video for 100 GB, it is clear that browsing and searching through such a collection requires sophisticated, usable and attractive user interfaces to achieve efficient and entertaining user experience.

The aim of this paper is to provide an overview of personal multimedia collection browser UIs available in present end-user media playback appliances and applications. Search and personalization issues have been scoped out. First, players are classified into six categories, and devices chosen for pattern observation are listed. A common unifying conceptual model for UIs is presented, and its relation to metadata standards is then briefly discussed. Views to the conceptual model are normalized, and navigation between them is examined in chapter 4. Common properties of widgets and important differences are described as well. Chapter 5 points out some problem areas in present digital media player UIs, and shows two alternative approaches to content browsing.

Besides directly accessible audio, video and image items, local library often contains objects that are stored on other physical media, like DVDs, CDs and VHS tapes, and there are dedicated librarian applications to handle this material. Online and broadcast content should be accessible ditto. Chapter 6 speculates whether this external content can somehow be integrated into the UIs overviewed earlier. Chapter 7 proposes an aggregated multimedia content browsing model. Finally, chapter 8 draws some conclusions.

A wealth of research effort has been put into usability testing, ethnographic studies and prototype implementations of multimedia information retrieval systems. For example, Rodden and Wood (2003) conducted a user study of a digital photograph collection management tool, which employed the basic folder-, timeline- and thumbnail-based browsing. In addition, items could be tagged with audio annotations that were later retrievable using text-based queries, and by content analysis that provided similarity-based browsing. Surprisingly, the advanced browsing methods were not commonly used, but browsing was rather based on specific events (which were modelled by timeline and folder structures). Cunningham *et al.* (2004) studied organization and access aspects of personal music collections in order to provide guidelines for system designers. They argued that a rich set of browsing categories is required, and that the user should be able to easily extend this vocabulary to gain more personalized browsing and sorting functionality. They also stressed that the screen size should be considered as an important design factor for portable devices. Lee and Smeaton (2002) describe a web-based video content browser for recorded TV programs, and provide an interesting state-of-the art survey of digital video library applications. However, despite of large amounts of reference material available, there are no compound surveys investigating commercial media player content browser UIs that I am aware of.

2. Player Classification

Media players were classified into six groups according to their portability, packaging and storage capabilities (cf. table 1). Devices having storage capacity less than 10 GB were generally Flash-based, while those with larger capacity used either embedded or external hard disks for content storage. The difference between portable media players and centers is that the media centers are more inclined to video viewing, and the difference between desktop media players and PC-based media centers is that the former is usually run as a windowed desktop application rather than in full-screen mode. Additionally, the latter has often support for TV broadcasts.

category	capacity (GB)	portability	packaging
A Mobile phones	< 4	portable	standalone
B Portable media players	1 - 8	portable	standalone
C Portable media centers	10 - 80	portable	standalone
D CE devices	40 – 160	static	standalone
E Desktop media players	100 – 1000	static	software
F PC-based media centers	100 – 1000	static	software

Table 1. Media player classification.

From each category, more than one device was selected for closer examination, which included reading product user manuals and reviews, viewing usage scenario walkthroughs and product marketing videos, and hands-on testing whenever possible. Some devices might be considered as belonging to multiple categories, because of technological convergence. Table 2 lists the chosen devices.

device	cat	GB	display	input
SE W850i	A	1	240x320 (2")	keys
Nokia N80	A	2	352x416 (2.1")	keys
Sony PSP	B	2	480x272 (4.3")	keys, thumbstick
SanDisk Sansa e200	B	8	220x176 (1.8")	wheel, keys
Microsoft Zune	C	30	320x240 (3")	keys
Archos 604	C	30	480x272 (4.3")	stylus, keys
Creative Zen Vision W	C	30	640x480 (3.7")	keys
Apple iPod video	C	80	320x240 (2.5")	wheel, keys
Medion MDC 4400	D	160	ext	IR remote
FS Activy Media Player 150	D	ext	ext	IR remote
Apple iTunes 7	E	ext	ext	mouse, keys
Windows Media Player 11	E	ext	ext	mouse, keys
Windows MCE	F	ext	ext	IR remote, mouse, keys
Apple Front Row	F	ext	ext	IR remote, mouse, keys

Table 2. Devices chosen for examination. The third column shows internal storage capacity (or ext if there is none).

3. Conceptual Model

A three level deep generalized model comprising Library, Container and Item was found to be sufficient to describe the seemingly different internal structure of the players. The model is shown in figure 1.

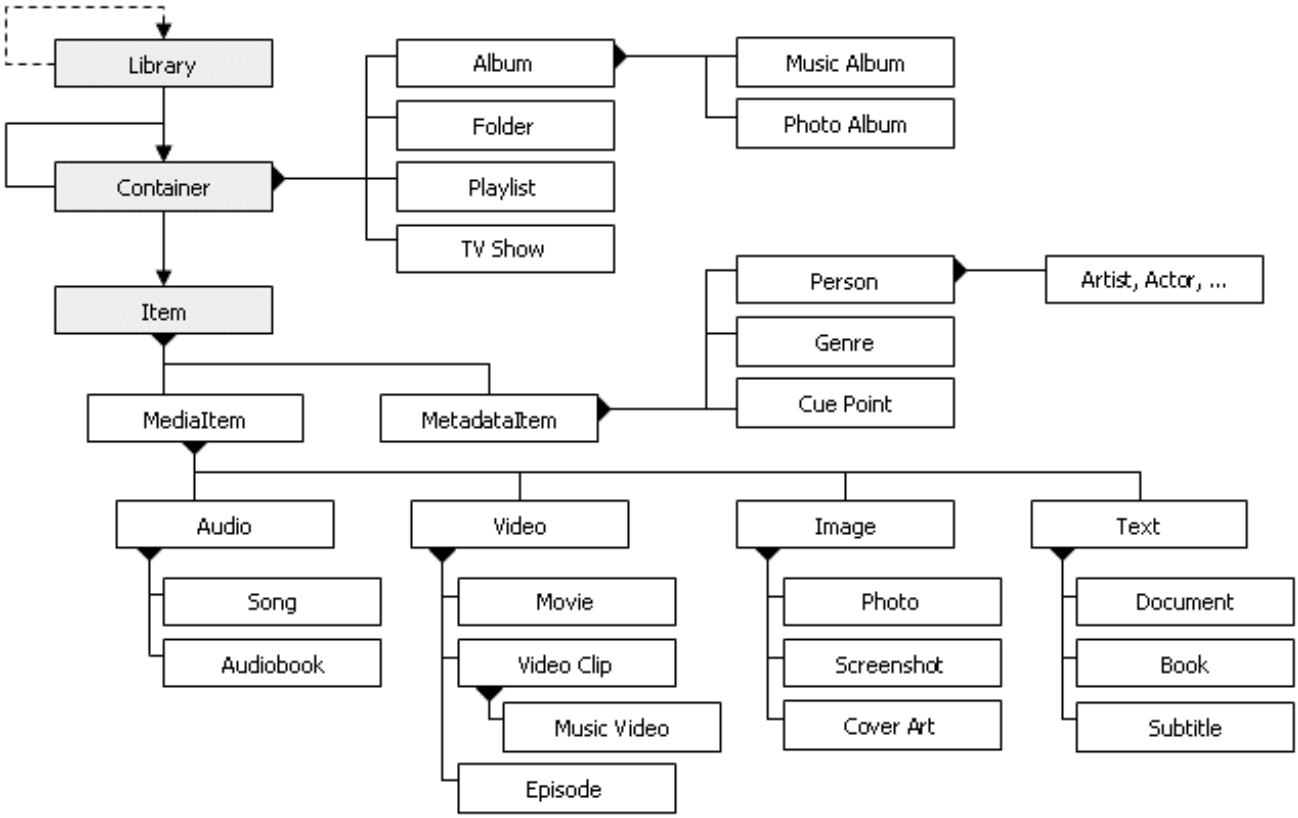

Figure 1. Conceptual model.

The topmost conceptual item is *Library*, which comprises entire local personal content. Portable devices are capable of holding only a subset of the Library in their internal storage at one time, and for this reason, they ship with a content manager application (running in a PC) for synchronization tasks. For iPods, this application is iTunes, for Microsoft's Plays For Sure devices it is usually WMP, although most manufacturers offer also a branded custom application for the purpose. In Creative Zen's content manager, Library is chunked into sublibraries (the maximum size of one sublibrary equals the capacity of one Zen), allowing one of them to be activated and transferred into the device. This is a brilliant idea, provided that sublibraries can be cross-browsed in PC. FS Activy can address UPnP servers one at a time, but this can be considered as a shortcoming, because server contents are totally independent of each other. Furthermore, FS Activy relies on server to provide the content hierarchy.

The second highest conceptual entity (in hierarchy terms) is *Container*, which groups objects according to some semantical reasoning. Container is either a flat ordered list of items (like playlist or favourite channel list), or a hierarchical structure allowing nesting (like user-defined tree of folders). There was a variation amongst players in the number of nested levels. Some smaller capacity devices allowed hierarchical nesting for some media types but grouped other types flat (Sansa), some restricted nesting level to one (Sony PSP). The most portable playlist format was m3u. Playlists can be divided into user defined and automatic lists (including play statistics, date and randomly generated lists).

The lowest level conceptual entity is *Item*, which can either be a MediaItem such as video, audio or image object, or a supporting MetadataItem like artist or album. MediaItems are usually atomic entities (which can be indexed with location bound markers such as chapters), but may in some cases be nested in a hierarchical manner. For example, a classical composition may consist of several movements. This was not utilized by any player under investigation, although the latest version of iPod is able to play succeeding tracks without gaps in between, should that be desired.

Common conceptual model was derived from DIDL-Lite (UPnP 2006), which combines elements from UPnP content directory service, MPEG-21 DIDL and Dublin Core. Library, Container and their subclasses are derived from object.container, Item and MediaItem are descendants of object.item, and MetadataItems are derived from object.container.person and genre classes. Only three elements do not exact equivalents in DIDL-Lite, and these are Video Clip, Subtitle (which is a time bound collection of texts) and Cue Point (representing time bound marker, such as chapter, section or repeat point).

4. Views and Widgets

4.1 Views

The primary filtering criteria of the Library seems to be media types, i.e., Music, Videos and Pictures. Some players include also top level choices of Recorded TV Shows, Radio, Podcasts and Audiobooks. The primary filtering criteria is mandatory, but succeeding criteria may be bypassed by selecting ‘All Items’.

The secondary filtering seems to be done according to Genre, or by Keyword if browsing Pictures. The third filtering option depends on the primary criteria, except that Ratings is available for all media types. For *Music*, items can be grouped by Artists/Albums, Year/Albums or by Albums directly (additionally by Composers or by Contributing Artists). *Videos* can be arranged by Actors/Movies or Artists/Albums in case of music video clips. *Pictures* can be

viewed by Album or Date. TV Show items are actually Episodes, which can be grouped by Actors/Shows/Season or Shows/Season. Radio items are live web streams that can be arranged by Stations (or channels). Player might provide also folder and device –based views, which are located at filtering secondary level.

The result view of filtering actions shows the (playable) media items and their most important attributes (number, title, duration, filtering criteria attributes, description, statistical info). Item list may be sorted according to any attribute, and in some cases, user can personalize what attributes to include in view. The result group is treated like a playlist, and might be storable for later retrieval. In general, Playlists can be selected either at the top level, or below media type (e.g., Music/Playlists, effectively disabling cross media type lists).

Now Playing screen is dependent on media type. For music tracks, usually track number, title, album, artist and duration are displayed. Current position with progress slider is common as well, and album art is displayed if it is available. Music tracks may show also visualization effects. For videos and pictures, now playing is usually shown as OSD textual information.

4.1.1 Navigation Between Views

Switching to another primary filtering criteria was possible only via top level view, and in most cases, user has to navigate from result view to the top, and then downwards again. This takes at least four navigation steps in most portable players, and might take even as much as eight. Secondary filtering criteria switching takes half of that, although Zune provides a usable horizontal navigation shortcut called twist (cf. 4.2.1).

4.2 Widgets

The choice of widgets is influenced by available input mechanisms and by the amount of screen estate. Despite visual differences, the underlying principles of interaction were in general the same in all players, and the widgets could be divided into standard controls (tree, list, grid) and into planar and pseudo 3D controls. Popup menus, buttons, layout controls were naturally used as well, but they were not analyzed.

4.2.1 Standard Controls

Tree widgets are capable of expanding and collapsing parent nodes in order to show or hide child nodes that lie beneath them. Child nodes are intended to the right to indicate their position in the hierarchy. Each tree item consists usually of an expansion handle, an icon and a text label. Lines may be drawn so that the tree structure is more clearly visible. Tree widgets were employed only by desktop media players and Archos, because the most convenient input device in this case is the mouse or stylus (albeit they do have keyboard interface as well). They also require a fair amount of screen space.

List widget groups items into a scrollable vertical one-column array, allowing user to select one or multiple choices. Activation is a two step process: item is first highlighted by single click, tap or cursor key press, and then clicked or tapped again (constituting a double click) to select it. Keyboard interface binds either right arrow key or enter/ok key for select action. For output, item may consist of an icon/thumbnail and one or two lines of text. Some small screen devices provided ticker-like automatic scrolling to reveal hidden parts of the text label. Two column items were used to indicate name and value pairs.

List widgets were the most common controls in devices that were investigated. This is because they adapt well to keyboard input mechanism, require only relatively small screen space, have fixed visible size, and because navigation, choice selection and invocation actions can all be made using just a single control. Their downside is that if they are used in hierarchy browsing, there is no indication of current level. This was handled in some cases by setting the caption of the control to current navigation path. SE W850i uses symbolic icons for indication.

List can also be horizontal. Zune has a clever option that reduces number of clicks when navigating between different sibling views of single parent. At the top of the display there is a horizontal strip ('twist'), and beneath that, a vertical list of choices. When user selects an item from the list, list contents are transposed into horizontal list that is displayed in twist (current selection is highlighted), and items belonging to the selected are shown in the vertical list. Right and left arrow keys are used to navigate the twist (i.e., to change parent level), and up and down keys to navigate the list (i.e., to make a choice and possibly a transition into a new twist/list pair).

Grid control is a multicolumn list widget. It is best suited for displaying items (rows) that have similar attributes (columns). Choice of attributes can be personalized. The downside is that the control requires large amounts of display space, and for this reason, they were only used by players that had external displays.

Figure 2. Standard widgets. a) tree b) list c) twist d) grid

4.2.2 Plane and Pseudo 3D Controls

Icon or image arrays are best suited for top level selections or to situations where individual items are different from each other and can thus be indicated by different graphics. Top level choices can also be presented by special list style controls, where viewport stays at a fixed position at the center of the screen, and the world behind the viewport is scrolled.

Sony PSP and some parts of Windows MCE use the entire screen space for navigation. Available categories and options below each category are gathered into a 2D grid. Once again, the viewport stays at a fixed location, and the grid below the viewport is scrolled in xy-plane. Only currently active column and row are visible, forming a cross of categories and currently available options (these may even be translucent). Navigation is done using arrow keys, and animation is provided for additional screen candy.

Figure 3. Plane widgets. a) image array b) fixed viewport c) cross

Finally, iTunes and FrontRow contain pseudo 3D user interfaces for top level and cover art based browsing. In FrontRow, the top-level selection of media type (Music, Videos, Photos, DVD) resembles a rotating carousel seen from a lifted position from horizontal level. iTunes 7 contains a 'cover flow' view that shows a stack of CD covers (arranged by artist or by album) in tilted perspective, with the currently selected one in the middle. Covers can be browsed using a scrollbar showing an attractive animation effect.

Figure 4. Pseudo 3D UIs. a) carousel b) cover flow

5. Problem Areas and Some Alternative Browsing Solutions

Some problems were noticed during analysis. Because top level choice (usually Music / Videos / Photos) has to be made before any other filtering action, there is no option to browse the entire collection. For example, it is impossible to list all media items of specific artist. iTunes groups music tracks and music videos under top level Music category if metadata for the video clip has been set up properly, but in general, cross browsing has to be made using text search functionality. Chapter 7 proposes a browsing model that allows any second level filter collection to be used as the primary sorting criteria.

Another problem is that connected devices and applications in categories D-F do not facilitate browsing across multiple media servers. FS Activy 150 can address only one UPnP server at a time, and one has to navigate through setup screens to acivate another server. While source -based filtering might be desirable, it should be included as a top level filtering criteria, and ANDed with media type selection. This is also addressed by the proposed model of 7, and has already been implemented in TVedia (cf. chapter 6.1). Among other integration features, TVedia allows also iTunes FairPlay and Windows Media DRM -protected content to be accessed using a single player interface, which is impossible in all players under investigation.

Furthermore, all browsing was based on metadata or on user-defined folder structure. This might be sufficient in most cases (as metadata creation can be automated and seems to be remarkably well supported in content manager applications and software -based players). Advanced content analysis algorithms can provide additional information that is not supported by metadata, and this option was totally ignored in most players. SE W850i utilizes a web service that can identify a piece of music from a short sampled fragment of a song, and provide accurate metadata that can then be used in purchasing or subscription transactions. One example of combined content and metadata based browsing interface is illustrated by Artist Map, which is briefly described in chapter 5.1 below.

Finally, automatic smart playlist creation was supported by many players, and is taken to the extreme by iPod Shuffle which works on the assumption that user often wants to listen to something, rather than to browse his way to a specific item. Probabilistic or statistic playlist creation can provide unexpected and fresh ways to experience content, but as the sizes of libraries continue to grow and online subscription services and communities make available selection still wider, entirely new ways of browsing might be considered. Musicream described in chapter 5.2 takes such a novel approach.

5.1 Artist Map

Artist Map visualizes music collection in form of 2D map, organized into clusters based on similarity (van Gulik *et al.* 2005). Mood, genre, year and tempo can be used as categorizing criteria, where latter is taken from content analysis. Two of these categories (e.g., year and tempo) can then be chosen to define x and y axels, or one of them can be used to define a circle across the visible plane (e.g., genre). Predefined anchor points provide the scale, and behave like magnets to populate the space with individual items from media collection (visualized as colored spheres, cf. figure 5). Artist names are overlaid atop of the visualization. Stylus is used as an interaction device, and user is able to zoom and pan to see different portions of the collection.

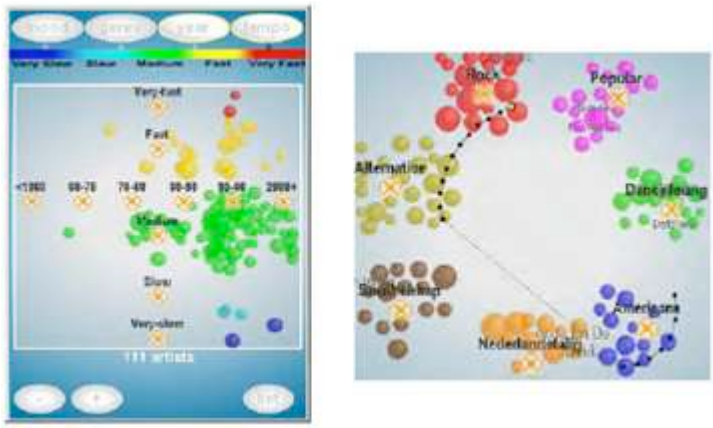

Figure 5. Artist Map. The path in right represents a playlist.

5.2 Musicream

Musicream allows probabilistic source material selection, similarity-based (meta) playlist creation and management, and browsing and replay of past music listening sessions (Goto 2005). Figure 6 shows screenshots of the main functionality of the UI, although a better way to understand the dynamics is to view presentation videos available from referenced site.

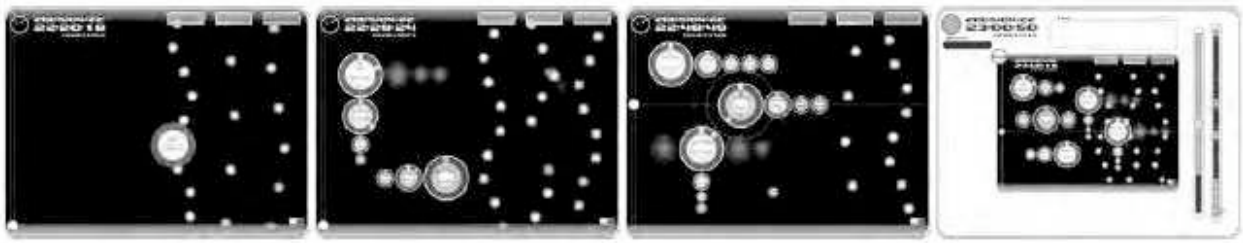

Figure 6. Musicream UI.

The right side of the UI contains three taps, which drop continuous probabilistic stream of media items in three different moods. The user can actively select items from these 'recommendations', view their metadata and listen to them. When he finds an interesting item, he can pick it up and drag it around to make a contact with other discs falling from the taps. If the similarity between discs is high, they affect each other like magnets, while those having less similarity have to make contact many times. The discs that have made a contact stick together like pearls in a string, and the collected playlist can be dragged as a whole to an empty position at the left side of the screen. The user is then able to rearrange, remove, and start playback from any position in the list.

Multiple playlists can be arranged into the left space this way, and a series of playlists can then be played back in top-to-bottom order. Horizontal playback bar can be dropped from the top of the screen to start the playback. After playback bar reaches the vertical center position of a disc string, playback is started from the first disc, and then continued through the playlist in horizontal direction. When last disc in a row has been played, the bar continues towards the bottom part of the screen, stopping whenever encountering an active playlist, and starting the playback for that playlist.
Finally, Musicream records each action made by the user, and allows backwards browsing in time to recall scenes from the past. There are two sliders that allow coarse (date) and fine (time) scale browsing. By clicking a specific media item, usage-based search and similarity based search is triggered simultaneously from the pool of previous activities. Usage matched scenes are presented as thumbnail screenshots at the left side of the UI, while similarity based search results a row of screenshots that are displayed horizontally at the bottom of the UI.

6. External Content

Previous chapters have concentrated on local content that either resides in player's internal storage, or is accessible via LAN using PC file sharing or UPnP media server functionality. However, personal multimedia content is not always in a format that can be consumed by the media player engine. External DVDs, CDs and VHS tapes can be managed using dedicated librarian applications that are able to fetch metadata information from online databases, and provide advanced cataloguing, browsing and searching services through proprietary user interface. Personal content is also increasingly being published in internet shares such as Flickr and YouTube, and membership in online communities is bound to widen the scope of personal content. Furthermore, online stores, VoD, Podcasts, live internet radio and television streams, P2P distribution and DVB companies offer content that is likely to be added into one's personal multimedia library.

It would be beneficial, if external offline and online content could be browsed in parallel and in the same manner as local content. This is to some extent already possible in PC-based media centers and portable media device content management applications, as online stores and

subscription services are part of the companies' business models (e.g., iTunes Store, Zune Marketplace, MCE online spotlight). There are also some third party plugins available for PC media centers that allow photo or video browsing and streaming from online communities. They are not entirely consistent with the user interfaces used in local content browsing, however. The following two solutions integrate external and local content more seamlessly.

6.1 TVedia

TVedia is described as networked media center PC software (8 Dimensions 2006), which is able to access local content from shared network directories, multiple UPnP content directories, and protected material in both Windows Media DRM and iTunes FairPlay formats. It is also capable of browsing online content sources such as Flickr, YouTube, Google Videos, Live365 and Last.fm, and fetch metadata from Amazon and AMG. All browsing is done using centralized UI front end (open source XML and JavaScript), which has been designed to scale for both 10-feet and windowed desktop resolutions. Local content is served as an aggregate UPnP content directory (which can be browsed and searched), so the internal data structure is built on top of DIDL-Lite concepts.

Figure 7. TVedia UI.

6.2 Philips LifeStyle Home Menu

LifeStyle Home is Philips' research project that visions a concept for connected living (Philips 2006). The centerpiece of user experience in their concept is network enabled TV, which displays personalizable home menu, allowing access to local, online and broadcast content, and management of peripheral devices such as lighting or digital media frames. TV screen is divided into horizontal strips, one for each category (e.g., live TV, music, videos, photos, movies, online services, devices). Each strip or category is divided into frames, where the center one contains 'now Playing' thumbnail, and pressing left or right in remote control scrolls previous or next item into the center. Pressing remote's up and down buttons allows navigation between categories, the active one is expanded vertically. User is able to personalize which categories are visible, their vertical order, create new ones and fill them with local or online content and services. The latter are CE-HTML compatible web services, which are initially accessible from 'catalog' strip comprising individual services grouped into 'genres' as frames. Examples of genres are web radio, VoD, eBooks, News and Entertainment.

Figure 8. Philips LifeStyle Home Menu.

The system contains also a dedicated full screen music browser UI (cf. figure 8), which allows access to local and online music albums, tracks or videos. This pseudo 3D UI is visualized as a large wheel of album covers, which can be rotated horizontally (using different speeds). Music can be sorted at least by title and genre. When desired item is found, it is expanded and playback starts automatically. If selected item is an album, its tracks can be browsed with up/down gestures. There is another larger wheel of items available for online store browsing, and when an item is purchased, it is automatically transferred into the local library, making it available in the smaller wheel as well. Navigation input device is a transparent, tactile gesture-driven 2D touchpad.

7. Aggregated Content Browsing Model

As discussed earlier, current players do not facilitate cross browsing over entire media collection. This can be easily overcome by adding 'All Media Types' option to the top-level choices (beside Music, Videos, Photos and so on). This allows direct second level filtering, and queries such as 'all works by a specific artist'.

Other problem with present players is that they do not allow browsing across multiple media servers, and if they do, there is no way of browsing contents of a specific server. This can be solved by ANDing a 'Media Source' filter to the primary criteria, and as above, it has the option 'All Servers' to bypass, which is also the default. To support external content browsing, class hierarchy might look like the one in table 3. When referencing content, items should be prefixed with Media Source id. This must be done, because for example UPnP id uniqueness is guaranteed only within single server.

class	description
MediaSource	abstract
Device	abstract, hides middleware parlance
UPnPServer	UPnP AV ContentDirectoryService –compatible device / application
MobilePhone	e.g. simple HTML tagging content server
Application	e.g. iTunes or DVD librarian
WebService	e.g. Flickr, YouTube, Live365

Table 3. Aggregated Content Model

Using above augmentations for cross media type and multiple server browsing, for example following queries are possible (in SQL): `select title from MediaItem where author = 'artistName'` (without additions, MediaItem would not be directly queryable, and one would need to address one of its subclasses instead). `select href from Library where MediaSource.class = 'WebService' and title contains 'iPod'` (this is a pseudo query, which translates into WSDL or REST requests for all supported online content servers).

8. Conclusions

Because underlying data set is more or less equal in all digital media players, it was possible to derive a common conceptual model that covers individual player functionality almost entirely. Views and widgets were also found to be basically similar. However, no two players look and feel alike (user interface is one of the discriminating factors for manufacturers), and it was noted that some players offer smoother browsing experience than their rivals do.

Some problems were found in browser implementations, relating to cross media type, cross media server and external content addressing. Simple additions to the base conceptual model can offer this functionality.

As personal multimedia content libraries continue to grow in size, novel ways of browsing and choosing content should be utilized. In addition to hierarchical metadata based browsing, it may be beneficial to use methods that provide non-deterministic recommendations and choices based on similarity, style, mood and tempo. To provide this flexibility, efficient back end data mining algorithms and databases are needed.

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